

Radiolytic Production and Destruction of Sulfurous Compounds on Europa

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Continuous production and destruction of the sulfur compounds sulfur dioxide, hydrated sulfuric acid, and elemental sulfur by energetic particle impact has been proposed to explain Europa's infrared and visible absorption features (Carlson, Johnson, and Anderson, Science 286, 363, 1999). The distribution of Europa's hydrate, identified as hydrated sulfuric acid, shows an asymmetry between the leading and trailing hemispheres that is consistent with magnetospheric input and radiolysis processes (Paranicas, Carlson, and Johnson, this session). Measured particle fluxes at Europa, combined with experimental production and destruction efficiencies, can be used to estimate the equilibrium abundance of radiolytic compounds.

We are performing low temperature radiolysis measurements to augment existing radiolysis data of liquid and frozen aqueous solutions of sulfur, sulfides, and sulfates. Radiolysis of sulfur-water mixtures efficiently produces sulfuric acid, perhaps through chemical chain reactions. Sulfur dioxide radiolysis produces sulfate and sulfur trioxide that readily combines with water to form sulfuric acid. Production of sulfuric acid by radiolysis of sulfate salts, if present, may also be possible. Although no molecule is immune to radiolysis, acid and salt sulfates exhibit low destruction rates compared to many species. Magnesium sulfates lose Mg by proton irradiation. Sulfuric acid can lose sulfur dioxide under irradiation but the higher hydrates are relatively stable due to back reactions, so the abundance of hydrated sulfuric acid can be much greater than the abundance of other sulfur compounds. The time scale for the radiolytic sulfur cycle on Europa is a few thousand years.